Description

Optical unidirectional ring network

The invention relates to an optical unidirectional ring network according to the preamble of patent claim 1.

Known for the purpose of transmitting large data volumes are ring networks in which data are transmitted between different network nodes/terminals in a unidirectional or - mostly via two fibers - bidirectional fashion.

Known from the "22nd European Conference on Optical Communication" - ECOC 96, Oslo, pages 3.51 to 3.54 is a colored section ring in which a wavelength used only once is used in each case for transmission between two network nodes. As a result, it is possible in the event of interference to switch a standby connection with the same wavelength via the undisturbed part of the ring network.

The plurality of variants for add-drop modules with couplers and filters are specified in IEEE Photonics Technology Letters 6(1994), No. 6, New York, pages 760 to 763, "Optically-Amplified WDM Ring Network Incorporating Channel-Dropping Filters". Conventional filters are used for outputting and launching signals.

Add-drop modules which essentially have two couplers and a reflection filter are to be gathered from Electronics Letters 16 March 1995, Vol. 31, No. 6 pages 476 and 477. These add-drop modules are suitable only for specific networks, since signals of identical wavelengths are launched and output.

In Figure 2 in "Optical Fiber Communication Conference" 1992, San Jose 2-7, Optical Society of America, US, Washington DC 2006, pages 255-256, there is a description of an add-drop module having a plurality of conventional drop filters and add filters. A protection connection is set up in the usual way by feeding back the data.

Disclosed in Electronics Letters, GB, IEE Stevenage, Vol. 32, no. 3,1, February 1996, pages 234-235, "Increased Capacity in an MS Protection Ring Using WDM Technique and OADM: The Coloured Section Ring" is a protection method in which different wavelengths are used for individual link sections of a bidirectional ring network. A protection connection is made via a wavelength not used on the undisturbed sections.

Wavelength changes are required as a rule in order to reconfigure a ring network, that is to say to set up new logic connections. The aim with newly designed optical ring networks is for data to be dropped and inserted on the optical plane, and for reconfiguration to be a simple possibility. Moreover, it is also possible to implement the ring network including the add-drop modules (network nodes) as cost effectively as possible.

Such an add-drop module is specified in claim 1.

Advantageous developments of the add-drop module ring network are specified in the subclaims. A ring network implemented thereby is specified in claim 6.

A unidirectional ring network is particularly cost effective, since only one glass fiber is required for transmission, and the

network nodes can be of simple design. A unique assignment of transmission channels, and thus of the transmitted data signals to the network nodes is provided by the fixed assignment of a specific transmission channel or a wavelength, which is used only once in the ring network, to a network node. Since each network node receives the data signals of all other network nodes, the setting up of an arbitrary connection to other network nodes is possible by selecting an appropriate receiving filter. If a receiving filter which can be switched over or tuned is selected, any desired connections can be set up between all the network nodes. A plurality of filters also permits simultaneous connection to a plurality of network nodes.

A very simple design of an add-drop module or a network node results from the use of a coupler which is provided with a grating and thereby has filtering properties.

If higher demands are placed on the transmission integrity, it is possible to provide for backup circuits a second ring in which the data transmission is performed in the opposite direction.

Exemplary embodiments of the invention are explained in more detail with the aid of figures, in which:

Figure 1 shows an unidirectional ring network,

Figure 2 shows a obvious exemplary embodiment of a network node,

Figure 3 shows an exemplary embodiment according to the invention of this network node, and

Figure 4 shows a unidirectional ring network having a standby transmission ring.

A unidirectional ring network having a plurality of network nodes NA, NB, NC, ..., NN is illustrated in Figure 1. The transmission between arbitrary network nodes is performed using wavelength-division multiplex operation via a glass fiber 1 in a plurality of transmission channels

Λ_A to Λ_N, which have a prescribed wavelength spacing from one another. The transmission direction is marked by arrows.

The network node NA is illustrated as a block diagram in **Figure 2** in an obvious implementation. Network nodes serve the purpose of implementing different connections, which are always performed via transmission channels. Data signals to be output in the network node are denoted as drop signals (drop), those to be emitted being denoted as add data signals (add). Dropping, switching through or adding channels are also spoken of, the signals transmitted in these channels being intended, in the narrower sense. Reference symbols with identical indices are used for the transmission channels and the associated data signals. A data signal λ_A is transmitted in the associated transmission channel Λ_B.

The network node reduced to the essential functions of an add-drop module contains the series circuit of an amplifier 4, an output device 5 and a launching device 6. A wavelength-division multiplex signal of all the data signals λ_A - λ_N received via transmission channels Λ_A - Λ_N is present at the input 2. A single signal can be transmitted in each transmission channel (transmission band), or else a plurality of individual signals can be transmitted using wavelength-division multiplex operation or, of course, also using time-division multiplex operation.

The received signals are firstly amplified and then passed to the output device 5. There, all the data signals/transmission channels are firstly split up into two signal paths in a 1:2 coupler (branching device). All the transmission signals/transmission channels to be switched through, except for the transmission

channel Λ_A assigned to this network node, are switched through via a signal path; a transmission channel Λ_{DROP}

or the data signal λ_{DROP} thereof, for example the data signal $\lambda_{B,DROP}$, is output via the other signal path.

The transmission channel Λ_{DROP} to be dropped is selected by the output device, designed here as a wavelength filter. The wavelength filter is illustrated here schematically as a coupler 51 with a fixed bandpass filter 52, which can be switched over or tuned, and a bandstop filter 53. The channel λ_{DROP} is the only one in the passband of the bandpass filter 52. It is relayed to a user terminal, for example, via a drop output 7.

Instead of the dropped data signal/channel, an appropriate data signal $\lambda_{A,ADD}$ present at the add input 8 in the assigned transmission channel is added in this network node in the launching device 6, designed as coupler. This presupposes that the signal λ_A (loop return signal) already emitted from the network node A and received again via the ring at the input 2 must be blocked at the latest upstream of the launching device 6. Provided for this purpose is the bandstop filter 53, which is situated in the first signal path and permanently tuned to the corresponding wavelength. The transmission of this signal can certainly also already be interrupted in the preceding network node MN, but this entails an additional outlay on configuration given additional further network nodes.

A wavelength-division multiplex signal containing the signals of all the transmission channels $\lambda_{A,ADD}$ and λ_B to λ_N is emitted at the output 3.

Each network node can receive the corresponding transmitted signal of each other network node, that is to say an appropriate connection can be set up, in each case by exchanging, switching over or tuning the band

pass filter 52. It is thereby possible to change the configuration in a simple way.

A network node according to the invention is illustrated in Figure 3. In this exemplary embodiment, a tunable bandpass filter 54 provided, and a coupler 61 provided with a grating 62 serves as launching device 61, 62. The wavelength-division multiplex signal coming from the amplifier 4 also contains the data signal λ_A, which has already transversed the entire ring network (loop return signal). The latter is reflected by the grating 62, which acts as a bandstop filter, and destroyed in an optical sink 63 (a suitable optical fiber termination). The signal $\lambda_{A,ADD}$ initially fed into the coupler contrary to the direction of transmission of the ring network is likewise reflected by the grating and thereby sent onwards in the transmission direction. Various structures are known for the coupler 61 provided with the grating. Either the grating is arranged in the coupling region (Figure 3), or two coupling regions are implemented between which separate gratings are respectively provided for each fiber.

Of course, it is also possible to implement connections to a plurality of channels between the individual network nodes. The add-drop modules illustrated in Figures 2 and 3 can be connected in series or appropriately adapted for this purpose. The joint outputting and launching of a plurality of adjacent channels is also possible for the use of wider filters.

Figure 4 shows an expanded ring network in which the optical fiber 1 is supplemented by an optical fiber 1P provided for protection purposes. In the event of a breakage or some other disturbance affecting the optical fiber 1, the data signals - only the protection data signal λ_{AP} being illustrated - are firstly transmitted via the undisturbed portion of the ring network and then fed in the opposite direction into the

protection optical fiber 1P, so that all the network nodes receive the data signal. The selection of the transmission path is performed by changeover switches provided in the network nodes.